Fuzzy Monitor Optimization Method in a Regional Economic System Based on Genetic Algorithm and Its Simulation

Shi Zheng [#1], Wen Zheng [*2], Jin Xia [#3]

[#]School of Economics and Management, Dalian Nationalities University

[*]Management Faculty, North-eastern University in Qinhuangdao

[1]Zhengshi1993@yahoo.com.cn; [2]zhengwen@mail.neuq.edu.cn; [3]Xiajin1998@yahoo.com.cn

***Abstract*-The purpose of this paper is to enhance the efficiency of monitoring and controlling a regional economic system by the optimization of the fuzzy membership function in the fuzzy controller. The paper improves the membership function by genetic algorithm and made a comparison with our prior research. The simulation results show that the improved controller has many advantages, such as accuracy, self adaptive, robustness and real-time. The method has more applying prospect that it can monitor and control a regional economic system effectively.**

***Keywords*-Genetic Algorithm; Fuzzy Controller; Membership Function; Fuzzy Monitor Optimization Method; Regional Economic System**

I. INTRODUCTION

The 'Membership function' has been applied in the intelligent control field [1], since Zadeh proposed this concept in 1965. However, the membership function should be optimized in the design of a fuzzy control system, so as to obtain better result. There are many optimization methods including Gradient method, Adaptive method and neural network method etc.. [2], these methods also have some limitations. Thus, finding a new method which can conquer the setbacks of the aforementioned approaches is a research hotpot. Due to its high efficiency, strong robustness, Genetic Algorithm (GA) is regarded as a major tool for the improvement of fuzzy membership function. The application of GA in this field can be categorized into three types [3-10]: (1) Optimizing the membership functions by GA when the fuzzy control rules has been known. (2) Optimizing the fuzzy control rules by GA when the membership functions have been known. (3) Optimizing both the membership function and the fuzzy control rules. These researches implicates that the optimization of the membership function is rather valuable than the optimization of the fuzzy rules. Therefore, this paper presents a fuzzy monitor optimization method based on GA. It designs a self learning fuzzy controller. The comparative simulation results show that the fuzzy controller based on GA has a superior control Quality.

The purpose of this paper is to enhance the efficiency of monitoring and controlling a regional economic system by the optimization of the fuzzy membership function in the fuzzy controller. It is meaningful that the experts' experiences can be fully used for the monitoring and controlling of the regional dynamics.

II. FUZZY MONITOR OPTIMIZATION METHOD

A. Fuzzy Control System

The fuzzy control system of a regional economic system is as follows (see fi1):

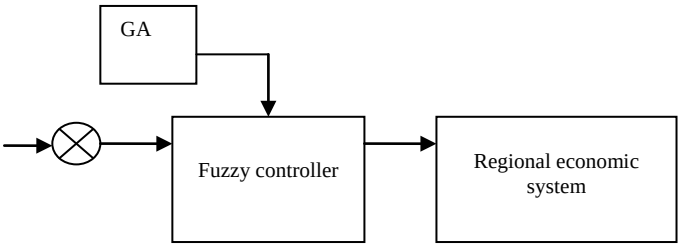


Fig. 1 Fuzzy Control System Based on GA

Among them, a regional economic system is a fuzzy system model which has two inputs and a single output. The two inputs are: regional competitiveness core-elements and auxiliary elements. The output is overall competitiveness of a regional economic system.

B. The Parameters Optimization of Membership Function Based on GA

Gauss membership function is adopted in the above fuzzy controller. .When the membership function by GA is optimized, the fitness function should be set. It is a difficulty because we should know under which conditions the membership function is the optimal.

Many researches show that the objective function form such as $J_{(ITAC)} = \int_0^\infty T|e(t)|dt = \min$ has the best control quality, when it is applied in the optimization of a control system. According to the requirements for the membership function optimization of a regional economic system, the fitness function is set as

$$J_{(ITAC)} = \int_0^\infty [\{-(\frac{x-c_i}{a_i})^2\}^{b_i} \exp-(\frac{x-c_i}{a_i})^2\}^{b_i}]dt = \min$$

In this paper, there are three parameters a_i, b_i, c_i in this fitness function. The adjustment of a_i, b_i, c_i is the major process for the parameters optimization in the GA Toolbox of MATLAB software. The steps are as follows:

1) Encoding the Parameters Need Be Optimized.

Encoding a_i, b_i, c_i into binary data, transforming the all encoded binary data into a string in binary (we also call it sample).

2) Population Initialized.

P individuals are generated as original population at random. Population is a array or a matrix composed by individuals. Population cannot be composed by little individuals; otherwise the varieties of the individuals in the population cannot be obtained. The limited optimization space will leads to advanced convergence of calculation process. Population also cannot be composed by large amount individuals; otherwise the calculation process will be complicated. The GA algorithm efficiency will be decreased.

3) Calculating the Fitness Value of Each Individual.

4) Selection.

Selecting two individuals from population p_t by probability p_i,and regarding them as parents' generation $p_{(t+1)}$, then the offspring generation can be generated. If the fitness value of the individual is f_i , the selection probability is $p_i = f_i \Big/ \sum_{i=1}^{n} f_i$.

5) Crossover.

Selecting two locations in the encoded string at random and exchanging the codes at the two locations. The offspring generation then can be generated.

6) Mutation.

Selecting a location in the encoded string of the two offspring generation samples at random and then calculating the value for anti-value (i.e. changing 1 to 0 or changing 0 to1). The mutation probability p_m equals to $0.001 - 0.01$.

7) Obtaining the Optimal Value

Go to steps 3) –6) until the overall fitness value becomes constant. At that time, the individual of the population has the same genes. The fitness value obtained is the optimal one.

III. SIMULATION RESULTS

A. Simulation Process

"Gatool","fuzzy logic "and "simulink" toolbox in MATLAB software is employed. The steps in details are as follows:

1) Optimizing the Membership Function of the Two Inputs and One Output in A Regional Economic System by GA.

The parameters description is: initial interval of the core-element is [0 0.2], initial interval of the auxiliary-element is [0 0.3], initial interval of the overall competitiveness is [0 0.2], initial population is 20, the variable numbers are 3 since the system has two inputs and one output, crossover probability is 0.8, mutation probability is 0.0002. After calculation, the optimal parameters a_i, b_i, c_i are as table I.

2) Loading the Parameters Value in Table II into GUI of the Fuzzy Controller, Designing A Fuzzy Controller Based on GA and Saving as "Garule.Fis".

The fuzzy rules in the latter are the same as the rules in literature [11].

3) Loading the 26 Pairs of Inputs and Output Data Generated by Fuzzy Evaluation from Workspace.

Applying "read fis ('garule.fis)" command, the fuzzy controller based on GA (i.e. garule.fis) has been loaded. The simulation curves can be obtained by the simulation model like the one in literature [11](see fig.2a).

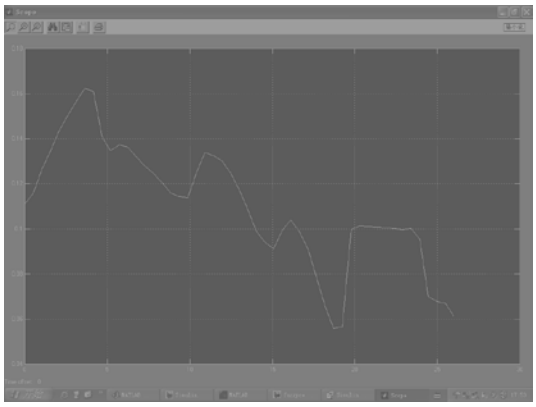
B. Comparison between Fuzzy Optimization Method and Classical Method

The output curves of fuzzy controller in literature [11] can be seen in fig. 2b. Since the fuzzy evaluation method is adopted as a reference method, the output curve of evaluation result is shown in the fig.3. Through the comparison result in fig.2a and fig. 2b with Fig.3, which was obtained from the

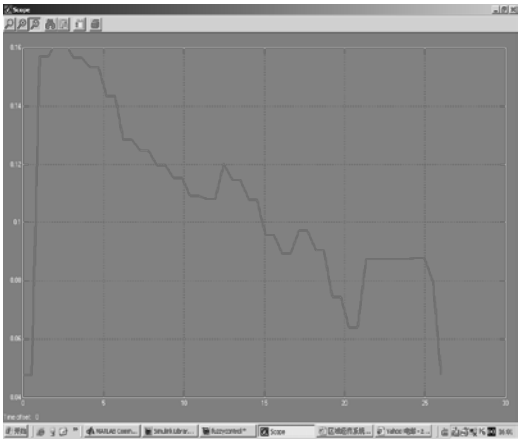
TABLE I PARAMETERS TABLE OF SUBSET MEMBERSHIP FUNCTION OF VARIABLES IN EACH MODEL

	Membership function of a_i			Membership function of b_i			Membership function of c_i		
Fuzzy interval	[0.06 0]			[0.01 0.1]			[0.02 0.2]		
core-element	-1.27277	-0.65747	0.05561	0.83764	-1.14627	0.15234	-0.74472	-0.63162	0.19768
Fuzzy interval	[0.08 0]			[0.04 0.15]			[0.08 0.3]		
auxiliary-element	-0.99232	-1.50574	0.11085	0.19928	-0.86754	0.16255	0.88952	-0.97325	0.26756
Fuzzy interval	[-0.03 0.03]		[0.03 0.1]		[0.1 0.16]		[0.17 0.19]		[0.19 0.22]
overall competitive-ness	0.9115	-0.96379	0.03174	-1.71501	-0.49536	0.06496	1.32507	-0.87528	0.15714	0.69004	-1.02622	0.18575	1.03377	-0.85619	0.19799

research in literature [12], we can find that the control quality of the fuzzy controller based on GA is superior to the fuzzy controller designed in literature [11].



a)



b)

Fig. 2 Comparison between Output Curves of the Fuzzy Controller Based on GA and Regular Fuzzy Controller

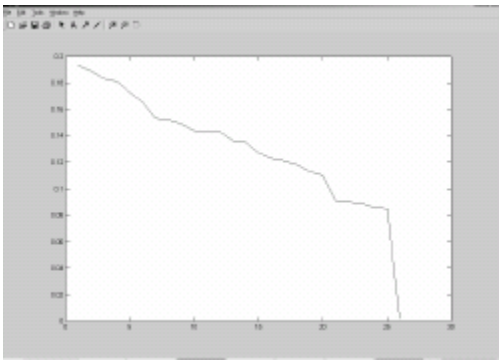


Fig. 3 Regional Economic Fuzzy Evaluation（Classical Fuzzy Evaluation Method）

IV. CONCLUSIONS

This paper makes use of GA to optimize the membership function of the fuzzy controller in a regional economic system. The algorithm can complete the optimal process within 100generations the convergence speed is fast. The local extremity can be overcome.

The method proposed in this paper can be applied under the conditions which the high stability of the system is required. It conduces to the improvement of the fuzzy controller in a regional economic system. Thus, it has a promising application prospect.

This research was limited by virtue of the fact that the application in a reality regional economic system was not made. The method can be applied in a specific region e.g. North-eastern Economic development in China. Employing the fuzzy optimization method, other researchers can make a deeper research in the relevant area, for instance, network marketing and e-commerce.

Up to the present, we have already developed a software package for controlling a regional economic system. We will combine the method into this software package. In the near future, the method will be verified by using the software in a specific region.

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Shi Zheng (1971, 9-) is associate professor in School of Economics and Management, Dalian Nationalities University, P. R. China. He got his P.H.D. in Management School of Harbin Institute of Technology, P. R. C. His academic career includes MIS (Management Information System) and applied technology, intelligent decision support system, and systems engineering. Besides his academic record, he has five years of industrial experiences with SMES' information system design and implementation. His research areas of proficiency include intelligent data mining, regional economic administration and e-commerce.

He has published articles in many refereed journals, such as Systems Engineering, Networks and Spatial Economics, International Journal of Communications, Network and System Sciences.

Dr. Zheng is currently serving as an editorial board member for an international journal and a Chinese journal.

Wen Zheng, Professor is the Vice Dean of Northeastern University at Qinhuangdao, PhD of Management Science. She graduated from the Management School of Harbin Institute of Technology and got her doctoral degree and pursuing her postgraduate study on the system simulation and the industry structure analysis. Now she has published over 30 papers on the focus area and a work paper of <The Simulation analysis of Network Industry--- The Adaptive Mechanism and Regulation Design of Telecommunication Enterprises>.

Jin Xia, Female, born in Apr., 1975. Now she is a lecturer in Dalian Nationalities University, P. R. China. Her specialty is industrial policy and tourism management. Her study interest focuses on cross industry development, especially on tourism industry policy. The Grey Theory and system dynamic method and fuzzy evaluation are applied to her research.

She has published some articles which indexed by EI, ISSHP, or the Reprinted Paper of Ren Min university. E-commerce and information technology, which applied into service industry, are her research focuses.